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Received: 26 March 2024 | Revised: 20 June 2024 | Accepted: 30 June 2024

DOI: 10.1111/jgs.19113

CLINICAL INVESTIGATION

Journal of the American Geriatrics Society

Clinical performance of existing diagnostic criteria for pneumonia in older emergency patients: A prospective cohort study

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Funding information
National Institute on Aging, Grant/Award Numbers: R01AG050801, R03AG064379

Abstract

Background: Pneumonia accounts for over half a million older adult emergency department (ED) visits annually, but ED pneumonia diagnosis is inaccurate. Geriatric-specific pneumonia diagnostic criteria exist for other settings; no prospective data exist to determine if application in the older adult ED population is feasible. The objective was to prospectively evaluate the utility of four current diagnostic criteria (Loeb; Modified McGeer; Infectious Disease Society of America/American Thoracic Society; American College of Emergency Physicians) in older adult ED patients.

Methods: This was a prospective, observational cohort study of older adult ED patients ≥65 years of age in two U.S. EDs with suspected pneumonia defined as having chest radiography ordered and treating physician suspicion. The standard we used for defining the presence, absence, or inability to determine a diagnosis of pneumonia diagnosis was expert physician chart

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adjudication. We report the summary statistics for demographic characteristics and symptoms/exam findings and sensitivity, specificity, and likelihood ratios with 95% confidence intervals of the existing diagnostic criteria. Pre-specified cutoff values of a positive LR >10 and a negative LR <0.3 were considered clinically significant.

Results: Of 135 patients enrolled, 27 had pneumonia by adjudicator review. Typical patient-reported pneumonia symptoms, such as fever (18.5%) and new/worse cough (51.9%), were not consistently present in pneumonia. The IDSA/ATS and ACEP criteria had positive LR >10 and negative LR <0.3; however, all confidence intervals included pre-specified cutoffs.

Conclusions: Older adults presented to the ED with low frequency of typical pneumonia symptoms. Although existing diagnostic definitions had promising test characteristics, they may not perform well enough for clinical application without refinement.

KEYWORDS

diagnostics, emergency medicine, pneumonia

INTRODUCTION

Pneumonia accounts for over half a million older adult (≥65 years) Emergency Department (ED) visits annually[1] and is the eighth leading cause of death in the United States.[2] Critical to high-quality care for older adults with pneumonia is fast, accurate diagnosis as both under-[3,4] and over-diagnosis[5,6] are detrimental. Most (75%) patients admitted for pneumonia are first treated in the ED[7] and ED treatment is known to impact inpatient care trajectories.[8–10]

Unfortunately, ED diagnosis of pneumonia is highly inaccurate with high rates of ED physician misdiagnosis (27.3%)[11] and uncertainty (47%),[12] administration of antibiotics without infiltrate on chest radiograph (37%),[13] delayed administration of antibiotics (22%),[14] and over-diagnosis (27%).[11] Notably, ED inappropriate administration of antibiotics to patients with suspected pneumonia may be harmful.[15,16] Potential challenges to accurate diagnosis in older adult ED patients include patient-factors such as atypical symptoms,[17–19] decreased sensation of dyspnea,[20] and multiple comorbidities[21,22] that can also contribute to dyspnea. Further, chest radiographs are unreliable in older adults due to nonspecific/absent/delayed findings,[23,24] dehydration,[25,26] aging-associated lung changes,[27] and inconsistencies among radiologists interpretations.[28] Importantly, no validated criteria exist for the diagnosis of pneumonia in older adults in ED or acute care settings.

The American College of Emergency Physicians' (ACEP) clinical policy and the Infectious Disease Society of America/American Thoracic Society (IDSA/ATS) guidelines for diagnosing a patient with pneumonia rely upon vague, even subjective, criteria of infiltrate on chest radiograph plus non-defined clinical signs and symptoms that are not validated and are not geriatric-specific.[29] Importantly, the IDSA/ATS guidelines note that both radiographs and clinical signs/symptoms may be unreliable in older adults.[29,30] Geriatric-specific criteria for pneumonia diagnosis exist, but were developed for other care settings.[31,32] The Loeb Criteria[31] were designed for long-term care facilities and the Modified McGeer[32] for disease surveillance. No prospective data exist to

Key points

- The majority of older adults with pneumonia as determined by expert chart adjudication did not present with typical symptoms; for example, only 18.5% had a fever.
- One quarter of patients with pneumonia did not have infiltrate on chest radiograph.
- Existing diagnostic criteria performed better than expected but likely do not perform well enough to be recommended for application to clinical care.

Why does this paper matter?

Existing tools require refinement rather than direct application in the ED setting.

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determine if these criteria can be applied to improve diagnostic accuracy in an older adult ED population.

The objective of this study was to prospectively evaluate the utility of the four diagnostic criteria (Loeb; Modified McGeer; IDSA/ATS; ACEP) in accurately diagnosing pneumonia in older adult ED patients.

METHODS

Study conduct

This was a prospective, observational cohort study of older adult patients ≥65 years of age who presented to the ED with suspected pneumonia. Age 65 was chosen given previous evidence, as discussed above, that this was a reasonable age capture the aging pathophysiology of interest. Patients were eligible for inclusion if the treating physician ordered chest radiography and had initial suspicion for pneumonia [score of 2 (unlikely) or more on 5-point Likert scale]. Physician suspicion was required so as to enroll patients in which pneumonia was part of the differential diagnosis but not enroll patients who presented with clear alternative diagnoses such as myocardial infarction. Exclusion criteria were inability to obtain consent from the patient or legally authorized representative (LAR), active cancer, organ transplant, immunosuppression, trauma activation, incarceration, or antibiotics in the previous 14 days. Enrollment via proxy was completed for patients without capacity via patient assent as in previous studies.[12,33,34] This study was approved by the institutional review board at our institution and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[35]

Patients were enrolled by research assistants in two U.S. EDs in the same hospital system, one academic ED with 76,000 annual visits (26% older adults) and one community ED with 46,000 annual visits (16% older adults). Enrollment occurred from 7 a.m. to 11 p.m. on all days of the week. Trained research assistants consented and enrolled eligible patients. Data were collected from the patient (or proxy) directly, treating physician directly, and via chart review by trained abstractors. Patient surveys included but were not limited to demographics, symptoms, and functional status. Physician surveys included but were not limited to patient symptoms, exam findings, imaging results and likelihood of pneumonia. And chart review collected test results in the ED and, if applicable, hospitalization.

Pneumonia diagnosis

There is no universally agreed upon gold standard for pneumonia diagnosis.[36] Therefore, the presence, absence, or inability to determine presence of pneumonia was determined by expert chart adjudication as done in ours and others previous work.[12,33,34] Prior to chart review, the adjudicators had a standardized training and had all questions answered. Each chart was independently reviewed by two randomly assigned attending physicians ("adjudicators") with a third reviewer if there was disagreement on pneumonia diagnosis between the two initial reviewers. Any remaining disagreements were resolved via in-person meeting. Adjudicators were aware of existing diagnostic criteria but were not required to follow them as there is no universal gold standard diagnostic criteria for pneumonia; they had access to all patient surveys as well as ED, inpatient and outpatient electronic health records.

Critical to ensure confidence in the adjudicator's determination was to include appropriate expertise to diagnose not only pneumonia, but also other potential etiologies of similar presentations. Therefore, the adjudicators were five attending physicians with training in emergency medicine, infectious disease, pulmonary/critical care, cardiology, and/or geriatrics.

Both adjudicator and emergency physician surveys evaluated the likelihood of pneumonia on a 5-point Likert Scale. For the purposes of all analyses, responses of 1 (very unlikely) or 2 (unlikely) were considered no pneumonia; 4 (likely) or 5 (very likely) were considered pneumonia; and 3 was considered unclear.

Data analysis

The demographic characteristics and presence of symptoms, exam findings and radiologic results of the enrolled patients are described as number and percent for categorical variables, and as mean and standard deviation for continuous variables.

We report the sensitivity, specificity, and likelihood ratios with 95% confidence intervals of the commonly used guidelines in emergency medicine practice (IDSA/ATS,[29] ACEP[30]) and the geriatric-specific criteria (Loeb,[31] Modified McGeer[32]) for pneumonia in the study population with the panel of experts as the criterion standard. As some information available in patients known to providers (e.g., in a skilled nursing facility) may be unavailable in the ED, we modified the criteria slightly (Table S1). If data were missing (e.g., acute functional decline), that was considered the same as negative for these guidelines/criteria as would be done in the clinical setting. Of note, the IDSA/ATS nor ACEP guidelines focus on the treatment/management of pneumonia but not how to best diagnose it. However, both include a definition of pneumonia that is applied clinically in emergency medicine. Thus, despite the anticipated limitations

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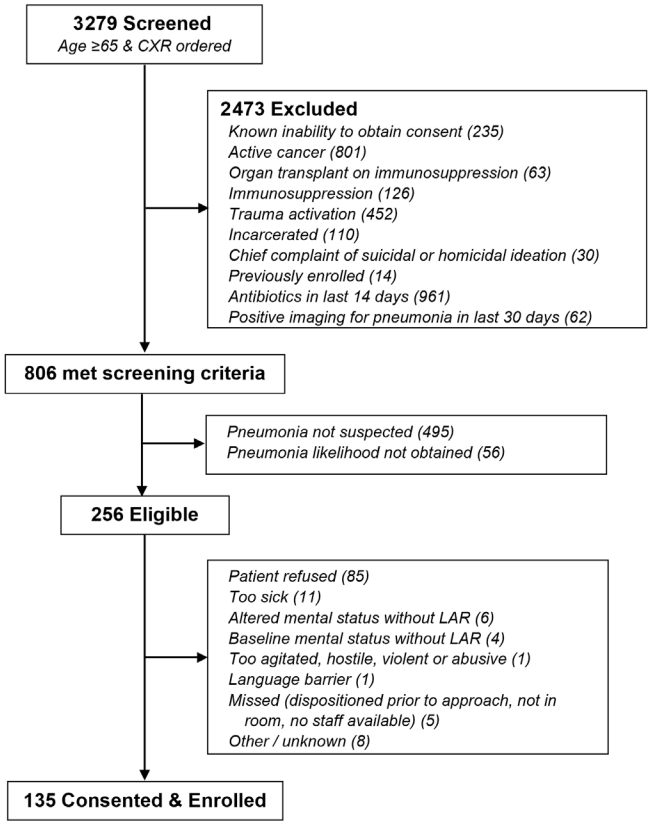
3279 Screened
Age ≥65 & CXR ordered
2473 Excluded
Known inability to obtain consent (235)
Active cancer (801)
Organ transplant on immunosuppression (63)
Immunosuppression (126)
Trauma activation (452)
Incarcerated (110)
Chief complaint of suicidal or homicidal ideation (30)
Previously enrolled (14)
Antibiotics in last 14 days (961)
Positive imaging for pneumonia in last 30 days (62)
806 met screening criteria
Pneumonia not suspected (495)
Pneumonia likelihood not obtained (56)
256 Eligible
Patient refused (85)
Too sick (11)
Altered mental status without LAR (6)
Baseline mental status without LAR (4)
Too agitated, hostile, violent or abusive (1)
Language barrier (1)
Missed (dispositioned prior to approach, not in room, no staff available) (5)
Other / unknown (8)
135 Consented & Enrolled

FIGURE 1 Enrollment flow diagram.

of IDSA/ATS and ACEP guideline definitions of pneumonia due to the vague criteria and lack of age-specific criteria, these were included as a comparator to provide context of the geriatric-specific criteria to current typical practice.

Sample size was calculated a priori for another aim of this investigation that sought to evaluate the difference in serum antimicrobial peptide (AMP) levels between older adults with and without pneumonia and required 135 patients. This sample size exceeded an a priori calculation for this analysis as it yields sufficient power to examine likelihood ratios having a moderate or greater effect on posttest probability of disease (LR[−] <0.3 and LR[+] >10.0).[37,38]

RESULTS

Patients were enrolled from October 3, 2019 to March 23, 2022 with an enrollment pause from March 10, 2020 to August 4, 2020 due to the onset of the COVID-19 pandemic. A total of 256 were eligible and 135 patients were enrolled with 26.7% LAR consent. The majority who were not enrolled were due to patient refusal ($n = 85$). Eligible patients who did not enroll did not differ from those who enrolled on available demographic variables including age and sex.(Figure 1)

Patient age ranged from 65 to 97 with an average age of 75.7 years. Approximately half were female (50.4%), White/Caucasian (74.8%) and lived at home (88.2%). Over 75% of participants presented with an Emergency Severity Index (ESI) of 1 or 2 and 20.7% were admitted to intermediate or intensive care. (Table 1).

There was agreement on pneumonia diagnosis among adjudicators on initial review for 110 patients (81.5%) with kappa of 0.572 indicating moderate agreement; after third adjudicator review 8 (5.9%) patients had remaining disagreements or desire for additional discussion. After group discussion, there was consensus on all diagnoses. Adjudication resulted in 27 (20.0%) patients diagnosed with pneumonia, 104 (77.0%) without and 4 (3.0%) with an indeterminate diagnosis. Comparatively, the treating emergency physicians diagnosed 37 (28.5%) patients with pneumonia, 47 (36.2%) without, and 46 (35.4) patients with an indeterminate diagnosis.

The presence of potential pneumonia symptoms on patient survey is reported in Table 2 and Figure 2. Typical pneumonia symptoms such as fever (18.5%) and new/worse cough (51.9%) were not consistently present in patients with pneumonia. Many reported symptoms by pneumonia patients were also reported by those without pneumonia. The range of symptoms reported was wide including some not typical of pneumonia, such as abdominal pain.

Tachypnea was the only abnormal vital sign that was present in the ED in more than 50% of patients with pneumonia. Fever both at ED presentation (14.8%, $p = 0.01$) and any time in the visit (29.6%, $p < 0.01$) was more common in those with pneumonia compared to those without and with indeterminate diagnosis.

Adjudicators reported presence of chest radiograph findings concerning for pneumonia in 74.7% of those with pneumonia, 7.7% without and 50.0% of indeterminate; among those who had CT performed as part of routine clinical care ($n = 32$), CT was concerning for pneumonia in 80.0% of those with pneumonia, 0.0% without and 50% of indeterminate. (Table 2).

Using the criterion standard definition (adjudicators) as in Table S1, the IDSA/ATS and ACEP criteria had positive LR >10 and negative LR <0.3 as pre-specified as considered clinically significant based on previous definitions[37,38]; however, all confidence intervals included these pre-specified cutoffs. Using the secondary definition as outlined in Table S1 (EM physician), only the ACEP criteria met the criteria; again, confidence intervals included the pre-specified cutoffs (Table 3).

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TABLE 1 Demographic characteristics of all older ED patients with suspected pneumonia and by adjudicator pneumonia diagnosis ($n = 135$).

		Pneumonia		
Patient characteristic	**All ($n = 135$)**	**Yes ($n = 27$)**	**No ($n = 104$)**	**Indeterminate ($n = 4$)**
Age, years [mean (SD)]	75.7 (8.4)	75.3 (8.8)	76.0 (8.3)	72.5 (10.0)
Female	68 (50.4)	13 (48.2)	52 (50.0)	2 (50.0)
Race				
White/Caucasian	101 (74.8)	23 (85.2)	76 (73.1)	2 (50.0)
African American	32 (23.7)	3 (11.1)	28 (26.9)	1 (25.0)
Other/unknown	2 (1.5)	1 (3.7)	0 (0.0)	1 (25.0)
Hispanic	1 (0.8)	0 (0.0)	1 (1.0)	0 (0.0)
Marital status				
Married	58 (43.0)	14 (51.9)	43 (41.4)	1 (25.0)
Never married	13 (9.6)	3 (11.1)	8 (7.7)	2 (50.0)
Divorced	32 (23.7)	4 (41.8)	27 (26.0)	1 (25.0)
Separated	1 (0.7)	0 (0.0)	1 (1.0)	0 (0.0)
Widowed	31 (23.0)	6 (22.2)	25 (24.0)	0 (0.0)
Education level				
Less than high school	13 (9.6)	2 (7.4)	11 (10.6)	0 (0.0)
High school graduate	36 (26.7)	8 (29.6)	28 (26.9)	0 (0.0)
Some college	44 (32.6)	11 (40.7)	30 (28.9)	0 (0.0)
College graduate	21 (15.6)	4 (14.8)	17 (16.4)	3 (75.0)
Graduate degree	19 (14.1)	2 (7.4)	16 (15.4)	1 (25.0)
Unknown	2 (1.5)	0 (0.0)	2 (1.9)	0 (0.0)
Place of residence				
Home/apartment	119 (88.2)	24 (88.9)	91 (87.5)	4 (100.0)
Assisted living	8 (5.9)	1 (3.7)	7 (6.7)	0 (0.0)
Rehabilitation	1 (0.7)	0 (0.0)	1 (1.0)	0 (0.0)
Skilled nursing facility/nursing home	6 (4.5)	2 (7.4)	5 (3.9)	0 (0.0)
Unknown	1 (0.7)	0 (0.0)	1 (1.0)	0 (0.0)
Emergency severity index (ESI) score				
1 (most urgent)	10 (7.4)	1 (3.7)	9 (8.7)	0 (0.0)
2 (emergent)	95 (70.4)	20 (74.1)	72 (69.2)	3 (75.0)
3 (urgent)	29 (21.5)	6 (22.2)	22 (21.2)	1 (25.0)
4 (less urgent)	1 (0.7)	0 (0.0)	1 (1.0)	0 (0.0)
5 (non-urgent)	0 (0)	0 (0)	0 (0)	0 (0)
ED disposition				
Admit to floor	81 (60)	15 (55.6)	63 (60.6)	3 (75.0)
Admit to intermediate or intensive care	28 (20.7)	8 (29.6)	20 (19.2)	0 (0.0)
ED or hospital observation unit	3 (2.2)	1 (3.7)	2 (1.9)	0 (0.0)
Discharge home	21 (15.6)	3 (11.1)	17 (16.4)	1 (25.0)
Transfer to rehab/SNF directly	2 (1.5)	0 (0.0)	2 (1.9)	0 (0.0)

Note: All data presented as *n* (%) unless otherwise noted.

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TABLE 2 Selected patient-reported symptoms and vital sign abnormalities in older adult patients presenting to the ED with suspected pneumonia by adjudicated final diagnosis.

	Pneumonia			
	Yes ($n = 27$)	No ($n = 104$)	Indeterminate ($n = 4$)	*p*-value
Patient-reported symptoms				
Fever (≥100.4 °F)	5 (18.5)	2 (1.9)	1 (25.0)	0.001
Chills	12 (44.4)	26 (25.0)	2 (50.0)	0.057
Confusion (reported)	9 (33.3)	32 (30.8)	1 (25.0)	0.850
Malaise	21 (77.8)	70 (67.3)	3 (75.0)	0.212
Shortness of breath	22 (81.5)	70 (67.3)	4 (100.0)	0.070
Rapid breathing	14 (51.9)	47 (45.2)	3 (75.0)	0.208
Difficulty breathing	17 (63.0)	58 (55.8)	3 (75.0)	0.259
Dyspnea on exertion	18 (66.7)	63 (60.6)	4 (100.0)	0.131
Orthopnea	16 (59.3)	50 (48.1)	1 (25.0)	0.163
New or worse cough	14 (51.9)	31 (29.8)	1 (25.0)	0.219
New or worse sputum	9 (33.3)	18 (17.3)	1 (25.0)	0.340
Chest pain	9 (33.3)	25 (24.0)	3 (75.0)	0.043
Chest pressure	7 (25.9)	24 (23.1)	2 (50.0)	0.228
Pleuritic pain	19 (33.3)	19 (18.3)	2 (50.0)	0.061
Increased oxygen requirement	14 (51.9)	28 (26.9)	1 (25.0)	0.044
Proxy-reported altered mental status	3 (11.1)	25 (24.0)	1 (25.0)	0.453
Initial vital signs				
Fever (≥100.4 °F)	4 (14.8)	2 (1.9)	0 (0.0)	0.014
Systolic hypotension (<90 mmHg)	2 (7.4)	3 (2.9)	0 (0.0)	0.500
Tachycardia (>100 beats per minute)	8 (29.6)	24 (23.1)	1 (25.0)	0.779
Tachypnea (>20 respirations per minute)	6 (22.2)	38 (36.5)	2 (50.0)	0.298
Hypoxia (<90%)	4 (14.8)	6 (5.8)	1 (25.0)	0.142
Worst ED recording				
Fever (≥100.4 °F)	8 (29.6)	3 (2.9)	0 (0.0)	<0.001
Systolic hypotension (<90 mmHg)	5 (18.5)	10 (9.6)	0 (0.0)	0.327
Tachycardia (>100 beats per minute)	9 (33.3)	35 (33.7)	0 (0.0)	0.369
Tachypnea (>20 respirations per minute)	21 (77.8)	80 (76.9)	3 (75.0)	0.991
Hypoxia (<90%)	9 (33.3)	20 (19.2)	2 (50.0)	0.128
Imaging concerning for pneumonia				
Chest radiograph	20 (74.1)	8 (7.7)	2 (50.0)	<0.001
Computed tomography ($n = 32$)	8 (80.0)	0 (0.0)	1 (50.0)	<0.001

DISCUSSION

We demonstrate variable symptoms and vital sign presentations in older adults with pneumonia and performance of IDSA/ATS and ACEP pneumonia criteria above pre-specified thresholds in a population of older adult ED patients. To our knowledge, this is the first comparison of existing pneumonia definitions to a criterion standard in the ED.

Our results are consistent with previous literature that older adults demonstrate an atypical presentation of pneumonia.[17–19] For example, while fever was more common in patients with pneumonia, fever was only reported by 18.5% of patients and present at any time in ED visit in 29.6% of patients with pneumonia. This suggests that emergency physicians must remain vigilant for pneumonia even in the absence of typical symptoms which may be absent or delayed.

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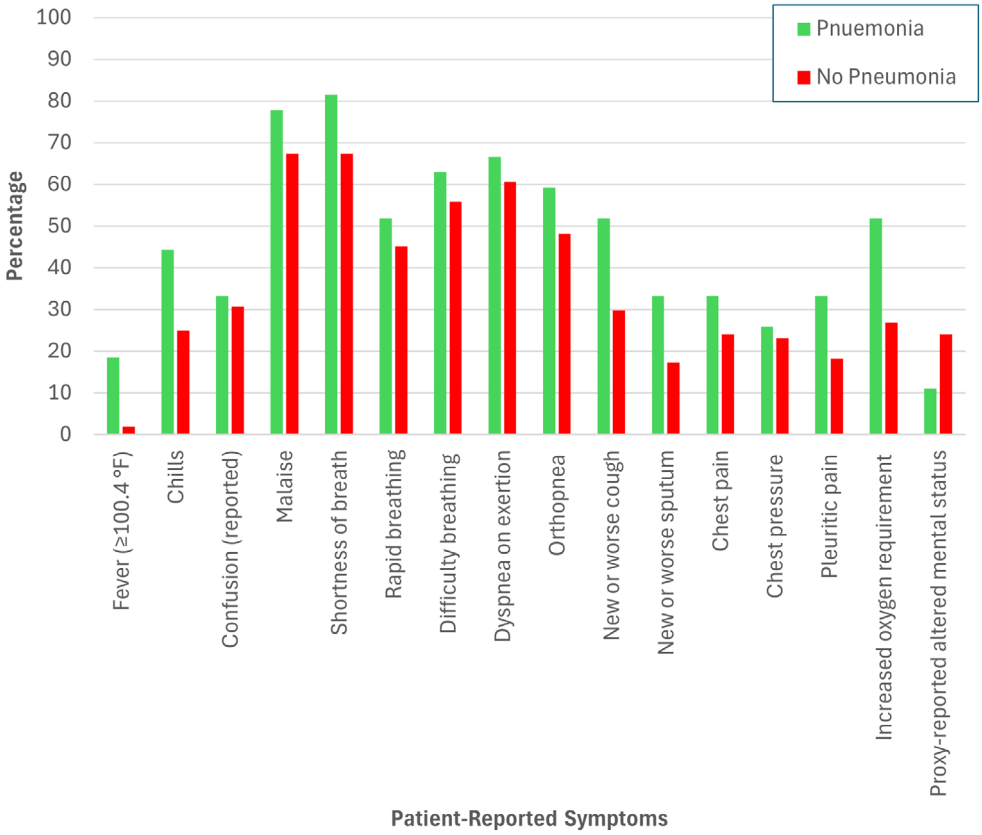

FIGURE 2 Percentage of older adult emergency department patients reporting symptoms in those with and without pneumonia as defined by expert chart adjudication.

TABLE 3 Performance of treating emergency physician and existing pneumonia criterion from Table 2 in older adults with suspected pneumonia with expert adjudication as the gold standard ($n = 131$).

		Sensitivity	Specificity	Correctly classified	Positive LR	Negative LR
Adjudicator definition	Loeb	7.4 (0.9–24.3)	95.2 (89.1–98.4)	77.1%	1.5 (0.3–7.5)	1.0 (0.9–1.1)
	Modified McGeer	33.3 (16.5–54.0)	95.2 (89.1–98.4)	82.4%	6.9 (2.5–19.0)	0.7 (0.5–0.9)
	IDSA/ATS	77.8 (57.7–91.4)	92.3 (85.4–96.6)	89.3%	10.1 (5.0–20.3)	0.2 (0.1–0.5)
	ACEP	74.1 (53.7–88.9)	96.2 (90.4–98.9)	91.6%	19.3 (7.2–51.7)	0.3 (0.1–0.5)
EM physician definition	Modified McGeer	40.7 (22.4–61.2)	92.3 (85.4–96.6)	81.7%	5.3 (2.4–11.9)	0.6 (0.5–0.9)
	IDSA/ATS	85.2 (66.3–95.8)	85.6 (77.3–91.7)	85.5%	5.9 (3.6–9.7)	0.2 (0.1–0.4)
	ACEP	81.5 (61.9–93.7)	93.3 (86.6–97.3)	90.8%	12.1 (5.8–25.3)	0.2 (0.1–0.4)

The IDSA/ATS and ACEP criteria have less strict definitions compared to Loeb and Modified McGeer. IDSA/ATS and ACEP preserved high specificity while demonstrating improved sensitivity over Leob and Modified McGeer. Our results suggest that in the ED, applying strict symptom criteria such as Leob and Modified McGeer may miss pneumonia diagnoses. The conclusions were similar regardless of the definition used (adjudicator vs emergency physician). Missed diagnoses can lead to delayed appropriate antibiotic treatment and have other deleterious effects.[3,4,15,16]

Due to the difficulty diagnosing pneumonia and risk for delayed treatment, the ATS/IDSA currently recommend empiric treatment with antibiotics.[29] Our results suggest that application of criteria derived specifically for the acute care setting could improve sensitivity so that clinical decision tool derived in older adult ED patients may out-perform both the existing criteria designed for other settings and emergency physician gestalt.

These results provide some clarity in the diagnostic performance of existing criteria in older adult ED patients with suspected pneumonia. However, these

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results do not answer all diagnostic dilemmas in this population. A critical remaining question is whether chest radiograph is sufficient or if computed tomography (CT) should be used due to the known limitations of chest radiograph in older adults. Previous literature comparing chest radiograph and CT suggests that CT may be superior to chest radiograph[39–42]; however, no study including this one has obtained both CT and radiographs in all comers but rather relied on those who had both ordered as part of routine clinical care resulting in biased samples with unclear generalizability. At this time, there is not sufficient evidence to recommend CT over chest radiograph in older adults with suspected pneumonia and care should be taken not to descend a "slippery slope" that has been observed with CT.[43–45] However, it is a critical question to answer and an NIH study is currently enrolling patients to answer this critical question (ClinicalTrials.gov ID NCT06092008). Moreover, this study was not powered to prospectively examine whether there is a constellation of symptoms specific to older adult ED patients with high sensitivity and specificity.

Further, ultrasound[46] and biomarkers may have a role in the diagnosis of pneumonia as well as determining the cause (bacterial vs viral vs fungal) across the age span but further research is required.

Strengths of this investigation include (1) prospective data collection with both patient survey and chart review; (2) enrollment included those with altered mentation; (3) inclusion of ill patients as demonstrated by high admission rates and ESI levels; (4) low risk of misclassification bias by adjudicators as data beyond the ED visit were reviewed. We believe this makes the results generalizable to a wide range of older adults including those who present to the ED but the results may have limited application in less acute settings such as urgent cares.

This investigation has several limitations. This is a convenience sample of patients available when research assistants were available; we have no reason to believe that patients presenting outside these hours are meaningfully different. A large number of patients refused enrollment. However, given the similarities between those who did and did not enroll, a significant number of LAR enrollments and inclusion of critically ill patients, we believe our sample is representative of the intended population. Patients with certain clinical conditions (e.g., immunocompromised or active cancer) were excluded due to concerns for effect on biomarkers being collected. This study did not differentiate between viral and bacterial pneumonia; this is consistent with the existing criteria as the ATS/IDSA state there is no current diagnostic test accurate enough to differentiate between the two and recommend empiric treatment with antibiotics.[29] Finally, not all patients had a CT, which may better differentiate pneumonia from other potential diagnoses.

CONCLUSIONS

Older adults presenting to the ED with treating physician suspicion for pneumonia often present with low frequency of typical symptoms. Application of existing pneumonia diagnostic definitions have high specificity but problematic sensitivity.

AUTHOR CONTRIBUTIONS

KMH, ALS, JAS, TRG, LCM and JMC obtained funding for this work and conceived the idea for this manuscript. KMH, ALS, ME, CH, BCL, LTS, EWB, TRG, LCM, MH, CBC, CR and JMC were critical in the conduct of the clinical study. KMH and JMC drafted the manuscript, performed revisions and contributed their expertise in the area. ALS, ME, CH, BCL, LTS, JAS, EWB, TRG, LCM, MH, CBC, and CR were responsible for critical revision of the manuscript for important intellectual content and their content expertise.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts to report.

SPONSOR'S ROLE

The funders had no role in the design, methods, subject recruitment, data collections, analysis, or preparation of this manuscript.

FINANCIAL DISCLOSURE

Dr. Hunold is supported by NIA R03AG064379. Dr. Caterino is supported by NIA R01AG050801.

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REFERENCES

1. Branch TAaHCS. *National Hospital Ambulatory Medical Care Survey: 2015 Emergency Department Summary Tables*. Centers for Disease Control; 2015.
2. Kochanek KD, Murphy S, Xu J, Arias E. *Mortality in the United States, 2016*. NCHS Data Brief; 2017:1-8.

15325415, 0, Downloaded from https://agsjournals.onlinelibrary.wiley.com/doi/10.1111/jgs.19113 by Cochrane Peru, Wiley Online Library on [16/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

3. Kollef MH, Sherman G, Ward S, Fraser VJ. Inadequate antimicrobial treatment of infections: a risk factor for hospital mortality among critically ill patients. *Chest*. 1999;115: 462-474.
4. Davey PG, Marwick C. Appropriate vs. inappropriate antimicrobial therapy. *Clin Microbiol Infect*. 2008;14(Suppl 3):15-21.
5. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis*. 2007;44:159-177.
6. Gordon LB, Waxman MJ, Ragsdale L, Mermel LA. Overtreatment of presumed urinary tract infection in older women presenting to the emergency department. *J Am Geriatr Soc*. 2013; 61:788-792.
7. Yealy DM, Auble TE, Stone RA, et al. The emergency department community-acquired pneumonia trial: methodology of a quality improvement intervention. *Ann Emerg Med*. 2004;43: 770-782.
8. Zalenski RJ, Compton S. Death trajectories of emergency department patients and palliative care service utilization. *Ann Emerg Med*. 2004;44:S68.
9. Kooda K, Bellolio F, Dierkhising R, Tande AJ. Defining antibiotic inertia: application of a focused clinical scenario survey to illuminate a new target for antimicrobial stewardship during transitions of care. *Clin Infect Dis*. 2022;74:2050-2052.
10. Eames J, Eisenman A, Schuster RJ. Disagreement between emergency department admission diagnosis and hospital discharge diagnosis: mortality and morbidity. *Diagnosis (Berl)*. 2016;3:23-30.
11. Chandra A, Nicks B, Maniago E, Nouh A, Limkakeng A. A multicenter analysis of the ED diagnosis of pneumonia. *Am J Emerg Med*. 2010;28:862-865.
12. Hunold KM, Schwaderer AL, Exline M, et al. Diagnosing dyspneic older adult emergency department patients: a pilot study. *Acad Emerg Med*. 2020;28:675-678.
13. Pines JM, Hollander JE, Lee H, Everett WW, Uscher-Pines L, Metlay JP. Emergency department operational changes in response to pay-for-performance and antibiotic timing in pneumonia. *Acad Emerg Med*. 2007;14:545-548.
14. Metersky ML, Sweeney TA, Getzow MB, Siddiqui F, Nsa W, Bratzler DW. Antibiotic timing and diagnostic uncertainty in Medicare patients with pneumonia: is it reasonable to expect all patients to receive antibiotics within 4 hours? *Chest*. 2006; 130:16-21.
15. Gupta AB, Flanders SA, Petty LA, et al. Inappropriate diagnosis of pneumonia among hospitalized adults. *JAMA Intern Med*. 2024;184:548-556.
16. Balen F, Lamy S, Froissart L, et al. Risk factors and effect of dyspnea inappropriate treatment in adults' emergency department: a retrospective cohort study. *Eur J Emerg Med*. 2024;31: 276-280.
17. Marrie TJ. Community-acquired pneumonia. *Clin Infect Dis*. 1994;18:501-513; quiz 14–5.
18. Bartlett JG, Mundy LM. Community-acquired pneumonia. *N Engl J Med*. 1995;333:1618-1624.
19. Metlay JP, Schulz R, Li YH, et al. Influence of age on symptoms at presentation in patients with community-acquired pneumonia. *Arch Intern Med*. 1997;157:1453-1459.
20. Petersen S, von Leupoldt A, Van den Bergh O. Geriatric dyspnea: doing worse, feeling better. *Ageing Res Rev*. 2014;15: 94-99.
21. Banerjee S. Multimorbidity—older adults need health care that can count past one. *Lancet*. 2015;385:587-589.
22. Dharmarajan K, Strait KM, Tinetti ME, et al. Treatment for multiple acute cardiopulmonary conditions in older adults hospitalized with pneumonia, chronic obstructive pulmonary disease, or heart failure. *J Am Geriatr Soc*. 2016;64:1574-1582.
23. Hagaman JT, Rouan GW, Shipley RT, Panos RJ. Admission chest radiograph lacks sensitivity in the diagnosis of community-acquired pneumonia. *Am J Med Sci*. 2009;337: 236-240.
24. Basi SK, Marrie TJ, Huang JQ, Majumdar SR. Patients admitted to hospital with suspected pneumonia and normal chest radiographs: epidemiology, microbiology, and outcomes. *Am J Med*. 2004;117:305-311.
25. Hash RB, Stephens JL, Laurens MB, Vogel RL. The relationship between volume status, hydration, and radiographic findings in the diagnosis of community-acquired pneumonia. *J Fam Pract*. 2000;49:833-837.
26. Hall FM, Simon M. Occult pneumonia associated with dehydration: myth or reality. *AJR Am J Roentgenol*. 1987;148: 853-854.
27. Gossner J, Nau R. Geriatric chest imaging: when and how to image the elderly lung, age-related changes, and common pathologies. *Radiol Res Pract*. 2013;2013:584793.
28. Pauls S, Kruger S, Richter K, et al. [Interobserver agreement in the assessment of pulmonary infiltrates on chest radiography in community-acquired pneumonia]. *Rofo*. 2007;179:1152-1158.
29. Mandell LA, Wunderink RG, Anzueto A, et al. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clin Infect Dis*. 2007;44(Suppl 2):S27-S72.
30. American College of Emergency Physicians Clinical Policies Subcommittee on Community-Acquired P, Smith MD, Fee C, et al. Clinical policy: critical issues in the Management of Adult Patients Presenting to the emergency department with community-acquired pneumonia. *Ann Emerg Med*. 2021;77: e1-e57.
31. Loeb M, Bentley DW, Bradley S, et al. Development of minimum criteria for the initiation of antibiotics in residents of long-term-care facilities: results of a consensus conference. *Infect Control Hosp Epidemiol*. 2001;22:120-124.
32. Stone ND, Ashraf MS, Calder J, et al. Surveillance definitions of infections in long-term care facilities: revisiting the McGeer criteria. *Infect Control Hosp Epidemiol*. 2012;33:965-977.
33. Caterino JM, Leininger R, Kline DM, et al. Accuracy of current diagnostic criteria for acute bacterial infection in older adults in the emergency department. *J Am Geriatr Soc*. 2017;65:1802-1809.
34. Caterino JMKD, Leininger R, Southerland LT, et al. Nonspecific symptoms lack diagnostic accuracy for infection in older emergency department patients. *J Am Geriatr Soc*. 2019;67: 484-492.
35. Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. *Epidemiology*. 2007; 18:805-835.

15325415, 0, Downloaded from https://agsjournals.onlinelibrary.wiley.com/doi/10.1111/jgs.19113 by Cochrane Peru, Wiley Online Library on [16/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

36. Waterer G. What is pneumonia? *Breathe (Sheff)*. 2021;17:210087.
37. McGee S. Simplifying likelihood ratios. *J Gen Intern Med*. 2002;17:646-649.
38. Irwin RJ, Irwin TC. A principled approach to setting optimal diagnostic thresholds: where ROC and indifference curves meet. *Eur J Intern Med*. 2011;22:230-234.
39. Claessens YE, Debray MP, Tubach F, et al. Early chest computed tomography scan to assist diagnosis and guide treatment decision for suspected community-acquired pneumonia. *Am J Respir Crit Care Med*. 2015;192:974-982.
40. Le Bel J, Pelaccia T, Ray P, et al. Impact of emergency physician experience on decision-making in patients with suspected community-acquired pneumonia and undergoing systematic thoracic CT scan. *Emerg Med J*. 2019;36:485-492.
41. Wang F, Li X, Wen R, et al. Pneumonia-Plus: a deep learning model for the classification of bacterial, fungal, and viral pneumonia based on CT tomography. *Eur Radiol*. 2023;33:8869-8878.
42. Loubet P, Tubiana S, Claessens YE, et al. Community-acquired pneumonia in the emergency department: an algorithm to facilitate diagnosis and guide chest CT scan indication. *Clin Microbiol Infect*. 2020;26(382):e1-e7.
43. Carpenter CR, Raja AS, Brown MD. Overtesting and the downstream consequences of overtreatment: implications of "preventing overdiagnosis" for emergency medicine. *Acad Emerg Med*. 2015;22:1484-1492.
44. Hoffman JR, Carpenter CR. Guarding against overtesting, overdiagnosis, and overtreatment of older adults: thinking beyond imaging and injuries to weigh harms and benefits. *J Am Geriatr Soc*. 2017;65:903-905.
45. Broder JS, Oliveira JESL, Bellolio F, et al. Guidelines for Reasonable and Appropriate Care in the Emergency Department 2 (GRACE-2): low-risk, recurrent abdominal pain in the emergency department. *Acad Emerg Med*. 2022;29:526-560.
46. Linsalata G, Okoye C, Antognoli R, et al. Pneumonia lung ultrasound score (PLUS): a new tool for detecting pneumonia in the oldest patients. *J Am Geriatr Soc*. 2020;68:2855-2862.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1. Visual abstract for social media.**Table S1.** Existing pneumonia criterion as applied from data available in emergency department.

How to cite this article: Hunold KM, Mion LC, Gure TR, et al. Clinical performance of existing diagnostic criteria for pneumonia in older emergency patients: A prospective cohort study. *J Am Geriatr Soc*. 2024;1-10. doi:10.1111/jgs.19113

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